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PROVISIONAL APPLICATION FOR PATENT COVER SHEET

This is a request for filing a PROVISIONAL APPLICATION under 37 C.F.R. 1.53(b)(2).

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TITLE OF THE INVENTION (280 CHARACTERS MAX)

SPACER PLATE SOLDER BALL PLACEMENT FIXTURE

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ENCLOSED APPLICATION PARTS (*CHECK ALL THAT APPLY*)

☒ Specification *Number of Pages* 5 ☐ Small Entity Statement

☒ Drawing(s) *Number of Sheets* 2 ☐ Other (specify)________

METHOD OF PAYMENT OF FILING FEES FOR THIS PROVISIONAL APPLICATION FOR PATENT (CHECK ONE)

	FILING FEE AMOUNT(S)	
☒ A check or money order is enclosed to cover the filing fees.		
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The invention was made by an agency of the United States Government or under a contract with an agency of the United States Government.

☒ No.

☐ Yes, the name of the U.S. Government agency and the Government contract number are: ________.

Respectfully submitted,

SIGNATURE Michael J. Doherty DATE May 30, 1997

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☐ Additional inventors are being named on separately numbered sheets attached hereto.

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SPACER PLATE SOLDER BALL PLACEMENT FIXTURE

Existing methods for placing solder balls on ball grid array packages have encountered quality problems. First, the flux placed on terminals to hold the solder balls in place can come in contact with the stencil used to align and place the solder balls on the terminals which may result in some of the solder balls sticking to the stencil rather than passing completely through the stencil holes. Another problem concerns insufficient stand-off between the terminals and the stencil. As a result, the solder balls placed in the stencil holes have a high profile at the top surface of the stencil and this situation may prevent other solder balls from moving freely across the stencil to fill other holes therein or may cause a ball positioned in a stencil hole to become dislodged therefrom.

In one preferred embodiment of the invention, a solder ball operation comprises four distinct processes: depositing a flux material on top of terminals; positioning solder balls on top of the flux pads; reflowing the solder balls to transform each ball into an intimate contact with the terminal; and defluxing or cleaning the terminals and solder balls to remove excess flux therefrom.

A microelectronic package may be manufactured by providing a package substrate, such as a polyimide film having terminals and leads extending therefrom and a semiconductor chip having contacts on a front face. After the leads of the package substrate have been electrically connected to the contacts on the semiconductor chip, the microelectronic package is prepared for being assembled to a supporting substrate such as a printed circuit board ("PCB"). The terminals on the package substrate must be electrically connected to the PCB for creating an

electrical interconnection between the semiconductor chip and the substrate.

Typically, solder balls are placed in contact with the terminals on the package substrate and the solder balls are reflowed to electrically interconnect the solder balls and the terminals. Fig. 1 shows a plurality of semiconductor chip packages 26 including semiconductor chips 26 and package substrates 24 having terminals 22 formed thereon. The terminals 22 are electrically connected to contacts on a semiconductor chip 26 using flexible leads (not shown). A flux material 20 is stencil printed onto the terminals 22 using a flux stencil 28 which is approximately 1 mil thick and has an array or matrix of holes 30 extending therethrough. A squeegee may be used to squeegee the flux 20 across a first surface 32 of the stencil 28 and through the array of holes 30 so that the flux 20 forms flux pads 20 having a thickness of approximately 1-2 mils on top of each terminal 22.

The package substrate 24 is then visually inspected under a microscope or using an automated vision system to ensure that the flux 20 has been properly disposed on top of the respective terminals 22. In one preferred embodiment, the diameter of the flux pad 20 is typically slightly larger than the diameter of the terminal 22, e.g., the terminal 22 is approximately 11.8 mils in diameter and the flux pad 20 is approximately 13-14 mils in diameter.

Referring to Fig. 2, solder balls 34 are then placed on the array of flux pads 20 using a ball plate stencil 36 having a top surface 40. In one embodiment, the solder ball 34 is 12 mils in diameter, comprises 63% tin and 37% lead, and reflows or melts at approximately 180-185°C. The solder balls 34 are aligned with the flux pads 20 using a stencil fixture comprising a frame (not shown), a spacer plate 38 placed over the frame, the ball plate

stencil 36 placed over the spacer plate 38 and a reservoir (not shown) for holding the solder balls prior to a stencil operation. The package substrate is placed in the frame in order to ensure proper alignment of the terminals on the package substrate 24 and the ball plate stencil 36.

The ball plate 36 is approximately 8 mils in thickness and the spacer plate 38 is approximately 4 mils in thickness so that the spacer plate 38 spaces the bottom of the ball plate 36 approximately 4 mils above the package substrate 24. This feature ensures that the ball plate 36 will not come in contact with the flux 20. As discussed above, if the ball plate 36 is contacted by the flux 20, the solder balls 34 may adhere to the stencil 36 and not be properly placed on the flux pads 20. In addition, the combined thickness of the ball plate 36 and the spacer plate 38 is 12 mils which is generally equivalent to the 12 mils diameter of the solder balls. This particular design ensures that the solder balls 34 will fall almost completely into the holes 42 in the stencil 36 and as a result the top of the solder balls 34 will not significantly protrude from the top surface 40 of the ball plate 36 thereby avoiding obstruction of the movement of other solder balls 34 over the top surface 40 of the ball plate 36. Further, this feature prevents solder balls 34 which have been placed in a stencil hole 42 from later becoming dislodged from the hole 42 by the movement of other solder balls 34 across the top surface 40 of the ball plate stencil 36.

After alignment of the stencil 36 over the flux pads 20, the stencil fixture and the ball plate stencil 36 are visually inspected to ensure that the matrix of holes 42 in the stencil 36 are aligned with the flux pads 20. A sweeper plate 44 is then used to sweep the solder balls 34 over the matrix of holes 42. The sweeper plate 44 may be approximately 5-6 mils thick and may comprise stainless

steel. In an alternative embodiment, a fine brush could be used to sweep the solder balls 34. Once the solder balls 34 fall through the matrix of holes 42 and touch the flux 20, the solder balls 34 will be held in place by the flux 20 which acts as an adhesive. The package substrate 24 is then visually inspected to ensure that a solder ball 34 has been disposed in each hole 42 in the ball plate stencil 36. The visual inspection may show that some of the solder balls 34 are not centered exactly over a terminal 22; however, this is not problematic because when the solder balls 34 are reflowed they will wet to the terminal 22 only and not the package substrate 24 and will thus tend to self-center on the terminals 22.

After the solder balls have been disposed on the flux pads the solder balls are reflowed to form a permanent bond at the terminals on the package substrate. There are a number of methods which can be used to reflow solder balls. Two methods which may be used are a forced air convection furnace method and a hot plate convection method. The particular methodology used depends on the diameter of the solder balls and the makeup of the solder balls. Generally, the package substrate including the solder balls is placed on a belt which passes the package substrate through a furnace to reflow the solder balls.

In the furnace, the solder balls are heated above a reflow temperature or melt point and maintained at that temperature for approximately 30-45 seconds. One preferred embodiment melts the solder ball in place over the terminals, letting the reflowed solder wet out to the terminal and then cooling the solder and letting surface tension reshape the solder into a sphere. The packages are in the furnace for approximately five minutes. After the solder drops below the reflow temperature, the solder ball solidifies and the solder is cooled down as it is removed from the other side of the furnace and off the belt.

The package substrate and reflowed solder balls may then be defluxed to remove excess flux therefrom. The defluxing process can be either a manual procedure or a fully automated procedure. In accordance with one preferred manual procedure, the package substrate bearing the reflowed solder balls is immersed in liquid alcohol for one minute in order to soften the excess flux at the terminal sites and the package substrate is then scrubbed with a brush to remove the excess flux therefrom. In accordance with one preferred automated procedure, a solution may be used to dissolve the excess flux and a mechanical action (i.e., scrubbing) is not required to remove the excess flux from the package substrate.

The present methods and apparatus can also be used in applying solder balls to microelectronic elements other than the package substrates discussed above. For example, they can be used to apply solder balls directly to microelectronic chips; to printed circuit panels such as ceramic or epoxy/glass ("FR4") circuit panels; or other devices.

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